Effect of Magnetic vs Sham-Magnetic Insoles on Plantar Heel Pain

A Randomized Controlled Trial

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Context Despite anecdotal reports, rigorous scientific evidence of the effectiveness of magnetic insoles for the pain of plantar fasciitis is lacking.

Objective To determine whether magnetic insoles provide greater subjective improvement for treatment of plantar heel pain compared with identical nonmagnetized insoles.

Design, Setting, and Participants Randomized, double-blind, placebo-controlled trial conducted from February 12, 2001, to November 9, 2001, of a volunteer sample of 101 adults with diagnoses of plantar heel pain for at least 30 days from a multispecialty group practice clinic in Rochester, Minn. Daily pain diaries were kept for 8 weeks.

Interventions Cushioned insoles, with either active bipolar magnets or sham magnets, which were worn daily by the participants for 8 weeks.

Main Outcome Measures Reported average daily foot pain (by metered visual analog scale [VAS] and by categorical response of change from baseline) at 4 and 8 weeks, and impact of insoles on employment performance and enjoyment.

Results No significant between-group differences were found on any outcome variables studied when comparing active vs sham magnets. Both the nonmagnetic and magnetic groups reported significant improvements in morning foot pain intensity, with mean (SD) VAS scores improving from 6.9 (2.3) and 6.7 (2.0), respectively, at baseline to 3.9 (2.6) for each group at 8 weeks ($P=.94$). At 8 weeks, 33% of the nonmagnetic group and 35% of the magnetic group reported being all or mostly better ($P=.78$). At baseline, foot pain interfered moderately with participants' employment enjoyment (mean VAS, 4.2) and improved in both groups by 8 weeks (1.3 and 1.5, respectively; $P=.68$).

Conclusion Static bipolar magnets embedded in cushioned shoe insoles do not provide additional benefit for subjective plantar heel pain reduction when compared with nonmagnetic insoles.

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THE USE OF MAGNETIC FIELDS FOR pain relief has increased dramatically in the past decade. Despite a paucity of scientific evidence and lack of approval by the US Food and Drug Administration, a large number of people use magnets to relieve their pain. An estimated $5 billion has been spent worldwide on magnetic devices purchased to treat pain,[1,2] with annual US sales estimated at $500 million.[3] The vast majority of devices available to and used by the general public are static magnets, typically ranging from 200 to 2500 G. Such magnets are generally considered safe when applied to the skin and have few adverse effects.[4,5] The physiologic effects of static magnets on pain, however, are largely unknown.[6-9]

Although some studies have found that bipolar magnets can relieve various sources of pain,[10-13] all had significant methodological flaws. Several other investigations have failed to show additional benefit from static magnets.[14-20]

Plantar heel pain, commonly referred to as plantar fasciitis, is a common condition among athletes as well as the general population.[21-23] The characteristic complaints are knife-like pain at the calcaneal insertion of the medial plantar fascia, typically worse on first arising in the morning, and often lasting months to years.[23] Many treatment regimens exist but effectiveness is variable.[24-26] Insole materials have generally been found to be effective in relieving signs and symptoms.[27-31]

We identified only 1 study in the medical literature evaluating the effectiveness of magnets for plantar heel pain.[16] This study found no difference in the effectiveness of a firm insole compared with an insole imbedded with a ferromagnetic foil, although there were several methodological limitations.[25]

See also Patient Page.

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We report a randomized, double-blind, placebo-controlled trial to assess the effectiveness of bipolar static magnets in insoles for treatment of plantar heel pain.

METHODS

Participants

Participants were recruited between February 12, 2001, and November 9, 2001, via referrals from clinics in the department of physical medicine and rehabilitation at the Mayo Clinic, Rochester, Minn, and from verbal and posted advertisements. The advertisements solicited adults with "foot pain for at least 1 month that is present more days than not," aggravated by standing or walking. Each respondent's eligibility was assessed via screening questions and a physical examination completed by 1 of 2 authors (R.G.B., M.H.W.). Inclusion criteria included 18 years or older; foot pain for at least 30 days occurring more days than not; foot pain intensity 3 or higher on a 10-point visual analog scale (VAS); maximal tenderness on palpation of the medial plantar fascia/medial calcaneus; sharp, shooting, or localized pain in the plantar aspect of the foot; pain exacerbated by standing, walking, or on first arising in the morning.

All potential participants underwent ankle examination and were excluded if they had evidence of chronic instability, ligament tenderness, cuboid syndrome, peroneus longus tendinitis, plantar nerve entrapment, or stress fracture. Participants were excluded for any neurologic deficit involving the lower extremities. Despite no documented adverse effects from static magnets, women likely to be pregnant (self-report of absent menses in the previous 2 months in premenopausal women) and individuals with electromagnetically activated implants were excluded. Approval from the departmental research committee and the institutional review board was obtained before initiating the study.

Interventions

The insoles were the Spenco "Active Comfort" magnetic insole (Spenco Medical Corp, Waco, Tex), which have a magnetic foil imbedded in foam under the proximal arch of the foot. The magnets have a bipolar multiple circular array, with internal magnetization to 2450 G. We verified surface magnetic field strength in a random subset of study insoles by using a hand-held gaussmeter (Lake Shore 410 Gaussmeter, Lake Shore Cryotronics Inc, Westerville, Ohio). The sham-magnetic insoles were identical to the active insoles, but were specially made by the manufacturer with the same metal foil, but in a nonmagnetized state.

All insoles (active and inactive) were provided by the manufacturer to the investigators at no charge and in a blinded fashion by using a random tracking code. The insole pairs were physically mixed in a box and were completely indistinguishable by appearance, touch, and location within a large box containing 116 magnetized and 117 nonmagnetized insole pairs. The investigators conducting enrollment, randomization, and insole distribution were blinded as to which type of insole was used. Ongoing blinding was encouraged by requiring all participants to sign an agreement to refrain from covert attempts to determine whether the insoles they were given had active magnetic properties.

Written informed consent was obtained for all eligible participants. Randomization occurred when the investigator stirred the unsorted insole pairs within the box and randomly chose a pair. Insoles were trimmed and placed in the participant's primary pair of shoes, with instructions to wear them for at least 4 hours per day, 4 days per week for 8 weeks. If different shoes were to be worn on a given day, participants were asked to transfer the insoles. Data were collected by questionnaire at baseline and 4 and 8 weeks, including pain intensity (10-cm metered VAS for morning, evening, and mean daily pain), categorical response to treatment (5-point Likert scale), adverse effects, and subjective pain-related interference with employment performance and enjoyment (10-cm VAS). Finally, participants were asked if they thought magnets have significant potential to relieve pain. Telephone reminders were used as necessary to encourage the return of questionnaires.

Participants kept diaries for 8 weeks, recording the number of hours insoles were worn and rating pain intensities daily. Participants were provided the insoles to keep at no charge and were given a $10 remuneration at the end of the study. No additional interventions were provided or suggested. Participants were discouraged from changing any current treatment regimen during the study period.

Statistical Analysis

The primary outcome variables were the 4- and 8-week categorical responses to treatment (all/mostly better vs somewhat better/unchanged/worse), as well as VAS scores. Based on historical outcomes,[31] we enrolled 82 participants to achieve 80% power to detect a categorical outcome difference of 30% between groups, with a significance level of .05. A 2-tailed alternative hypothesis was conservatively used a priori given the possibility that the magnets could have a poorer outcome than the controls, although no such reports are in the literature. An additional 19 participants were enrolled to maintain statistical power with anticipated participant dropout. All primary outcome analyses were performed according to the intent-to-treat principle. The proportion of participants who reported being all or mostly better was compared by using the χ^2 test. We also compared outcomes between participants who did vs did not believe in the potential of magnets to relieve pain. Two-group comparisons were performed at baseline to determine group comparability by using the nonparametric Wilcoxon rank sum test or Fisher exact test. SAS version 8.2 (SAS Institute Inc, Cary, NC) was used to analyze all data. All comparisons were considered significant at $P<.05$.

RESULTS

A total of 101 participants were enrolled in the study (80 women and 21 men). Six participants did not complete the study (FIGURE 1). All base-

Figure 1. Patient Flow Diagram

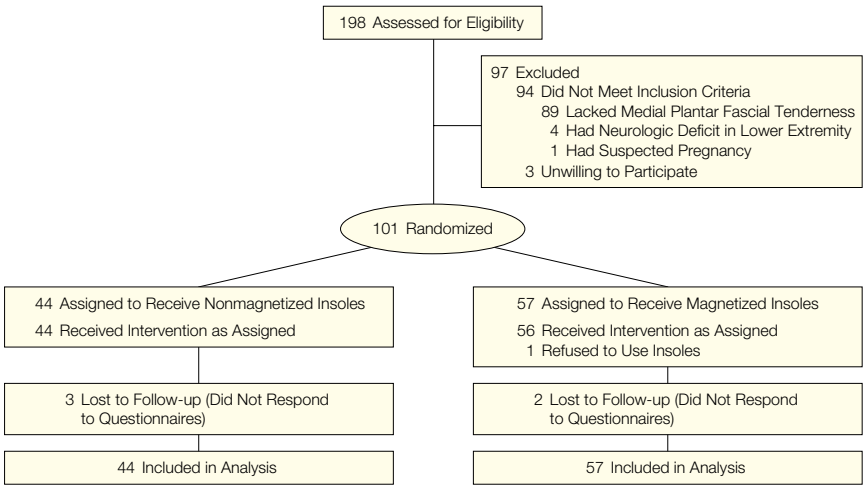


Table 1. Baseline Group Comparisons*

Characteristics	Nonmagnetized Insoles (n = 44)	Magnetized Insoles (n = 57)
Age, mean (SD), y	40.4 (8.9)	42.0 (9.5)
Sex, female†	30 (68)	50 (88)
Race, white	42 (95)	57 (100)
No. of hours worked per week, mean (SD)	39.1 (11.7)	37.3 (12.2)
No. of hours standing or walking per day, mean (SD)	8.2 (4.2)	8.7 (4.8)
Foot involved		
Left	8 (18)	15 (27)
Right	15 (34)	10 (18)
Both	21 (48)	31 (55)
Duration of pain, mean (SD), mo	120 (170)	85 (86)
Observed by health care provider	29 (66)	42 (74)
Used insoles before	32 (73)	45 (79)
How helpful were insoles in the past (range, 0-10), mean (SD)	4.5 (2.6)	3.4 (2.6)
Use of magnets for feet		
Past	2 (5)	2 (4)
Current	1 (2)	0
Pain in last month		
Worsening†	14 (32)	7 (13)
Improvement	1 (2)	3 (5)
Current treatment		
Doing nothing for pain	4 (9)	2 (4)
Stretching	28 (64)	36 (63)
Massage	18 (41)	30 (52)
Using NSAIDs	21 (48)	26 (46)
Elevating‡	9 (20)	22 (39)
Icing	12 (27)	18 (32)
Using acetaminophen	7 (16)	16 (28)
Hot soaks	9 (20)	11 (20)
Using other medication	4 (9)	8 (14)
Splint	1 (2)	4 (7)
Relax/deep breathing	1 (2)	1 (2)

Abbreviation: NSAIDs, nonsteroidal anti-inflammatory drugs.
*Data are No. (%) unless otherwise specified.
†$P = .02$.
‡$P = .04$.

line characteristics and treatment regimens were statistically comparable between groups, except sex, proportions with worsening pain, and use of leg elevation for relief (TABLE 1). However, subsequent adjustment for these variables using multiple logistic regressions did not alter any of the outcome results (data not shown). Occupations included secretary/data entry (n=21), nursing (n=20), technician (n=16), clinical assistant (n=9), administration (n=9), physician (n=5), food service (n=3), and miscellaneous (n=18). The 5 participants who were lost to follow-up did not differ from the others in terms of age, sex, duration or intensity of pain, or proportion with worsening pain at baseline.

A random sampling of 56 of the study insoles revealed surface readings of 2.2 G (range, 1.2-3.1; SD, 0.45) for sham insoles and 192.1 G (range, 178-200; SD, 8.53) for active magnetic insoles.

No significant differences were found between the magnetic and nonmagnetic groups on any of the primary outcome variables (VAS pain or categorical response to treatment) at baseline, 4 weeks, or 8 weeks. At baseline, most participants reported unchanging pain, although more in the nonmagnetic group reported actively worsening pain (32%) than in the magnetic group (13%, $P=.02$). At 4 weeks, 44% of the nonmagnetic group reported being all or mostly better compared with 31% in the magnetic group ($P=.19$; an alternate analysis with exact permutation also showed $P=.20$). The nonmagnetic and magnetic groups did not differ at 8 weeks with the proportions of 33% and 35%, respectively, of participants saying their pain was all or mostly better ($P=.78$) (FIGURE 2). These results were insensitive to imputations assigning either the best or worst possible values to missing observations in the 2 groups.

Participants in both groups had similar morning pain scores at baseline ($P=.64$) and both groups reported nearly identical improvement in morning pain at 4 weeks ($P=.63$), with little change by 8 weeks ($P=.94$) (TABLE 2). Again,

these results were essentially unchanged after imputing either best or worst possible values to the missing data.

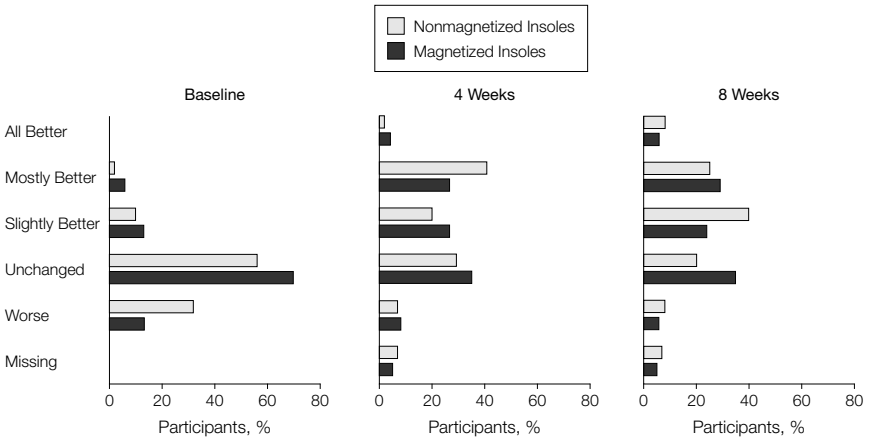
There were no significant differences in participants' reported ability to do or enjoy their employment during the study period. At baseline, foot pain interfered moderately with participants' employment enjoyment (mean VAS, 4.2) and improved comparably in both groups by 8 weeks (mean VAS improvements of 1.3 and 1.5 in nonmagnetic and magnetic groups, respectively; $P = .68$). However, categorical improvement in pain at 8 weeks (all or mostly better) did correlate with less interference in ability to enjoy their employment when compared with their own baseline responses ($P < .001$).

Compliance was equivalent between the groups, with 98% (nonmagnetic) and 92% (magnetic) of participants still wearing their insoles every or most days at 4 weeks ($P = .38$), and 83% and 87%, respectively, at 8 weeks ($P = .59$). Minor problems with the insoles were reported by 27% of participants in the nonmagnetic group and 13% in the magnetic group ($P = .11$) at 4 weeks, consisting primarily of tightness of shoe with the insoles and cosmetic breakdown of the insole surface material. No serious adverse effects were reported with any insoles, although one participant in the magnetic group reported foot spasms and another participant in the nonmagnetic group reported transient foot burning. Of the 95 participants with complete follow-up, 89 specifically reported beginning no new treatments during follow-up. The other 6 were equally divided between the 2 groups.

Participants were asked whether they thought they had received active or inactive magnets. Forty-two percent of participants in the nonmagnetic group and 48% in the magnetic group correctly guessed their group assignment at 4 weeks. At 8 weeks, 53% in each group guessed correctly, suggesting that adequate participant blinding had occurred.

There was no baseline difference between the groups in terms of the proportion of participants who felt magnets have a significant potential to relieve pain ($P = .28$). Of those participants (irrespective of group) believing in the potential of magnets, 15 (42%) of 36 had categorical improvement at 4 weeks compared with 17 (35%) of 48 who did not feel magnets have a significant potential ($P = .56$). At 8 weeks, these categorical improvements were 40% and 29%, respectively ($P = .30$). Participants believing in magnets also tended to have less morning pain at 4 weeks (mean VAS, 4.09 vs 4.88; $P = .23$) and had significantly less pain at 8 weeks (3.18 vs 4.70; $P = .04$).

Figure 2. Categorical Response to Treatment Compared With 1 Month Ago



Participants were asked, "Overall, how would you rate your foot pain now, compared with 1 month ago?" Missing data for 3 of 44 participants in the nonmagnetic group and 3 of 57 in the magnetic group.

Table 2. Morning Pain Intensity (Range, 0-10 Metered Visual Analog Scale)

	Insoles, Mean (SD)		*P* Value
	Nonmagnetized	Magnetized	
Baseline	6.9 (2.3)	6.7 (2.0)	.64
4-week*	4.2 (1.9)	4.4 (2.3)	.63
8-week*	3.9 (2.6)	3.9 (2.6)	.94

*Three participants in each group lost to follow-up for 4- and 8-week data.

COMMENT

Both groups used cushioned insoles and both reported subjective improvement in their symptoms; however, static magnets imbedded within these insoles did not provide additional relief. Many people use magnetic devices empirically and without specific diagnosis, and the results of this study may be generalized for people with common forms of plantar heel pain.

Although previous literature has not found the effectiveness of static magnets to be related to magnetic strength, it is important to note that the strength of magnets used in this study is comparable with widely available devices. We investigated several other brands of insoles and magnetic shoes available at local retailers. Using the same gaussmeter, maximum surface magnetism of these devices ranged from 35 to 236 G (data not shown) comparable with the 192 G in the studied insoles. Our negative results thus are not likely due to lack of magnetic strength.

The insoles in our study contained a metal foil in the arch area, magnetized in a bipolar multiple circular array. Other marketed insoles have varied configurations of magnets, which may or may not have different clinical effectiveness profiles. Pulsed electromagnetic fields, however, are less comparable and no conclusions should be drawn from this study on their effectiveness.

Although participants had the opportunity to test their insoles for magnetic activity, we doubt that many of them did. First, all participants signed an agreement and verbally committed not to test their insoles. While this could have incited curiosity, we thought the

honor system would be most effective to dissuade participants from testing their insoles. Second, participants in both groups correctly guessed their group assignment equally at a level no better than chance, suggesting that adequate and equal blinding had actually occurred.

The randomization in this study was based on an unpredictable physical device (drawing from an equal assortment of indistinguishable insoles from a large box). The unequal sizes of the treatment groups was a result of having more insole pairs in the box than we intended to use in this study, but in itself this assortment was a random event which did not introduce any systematic bias or alter the results.

Comparison of baseline characteristics revealed 3 statistically significant differences between groups. Other than possible clustering of covariates, there are no other identified causes for this number of differences, which would be expected about 13% of the time given the 25 comparisons in Table 1. The control group did have relatively more worsening pain at baseline, which could have represented more active disease. Active disease would be expected to improve more during follow-up and therefore mask true efficacy of magnets. However, baseline pain intensities were nearly identical between active and control groups, and the control group actually had a slightly longer duration of symptoms, which argues against more active disease. Finally, multivariate adjustment for baseline worsening/static, age, and sex (data not shown) all revealed no significant changes from the univariate results presented in our study.

There may have been minor differences in participants' compliance with insole use but with high rates of overall compliance and the even distribution between groups of the 6 participants who began new treatments during the study, it is unlikely that differences in compliance alone could explain our negative results.

Our results only marginally support the secondary hypothesis that participants believing magnets have a significant potential to relieve pain would be more likely to have a response to either intervention. Because participants were blinded, the magnitude of this placebo effect could be understated compared with devices purchased independently and known to be magnetic. Also, individuals volunteering for a study using magnets may have believed in the potential of magnets more than the general population but probably less than the typical consumer who purchases magnetic devices based on belief or personal recommendation. Although many claims have been made regarding the therapeutic use of magnets, our outcomes showed static magnets to be ineffective in the treatment of plantar heel pain.

Author Contributions: As principal investigator, Dr Winemiller had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Winemiller, Billow, Laskowski, Harmsen.
Acquisition of data: Winemiller, Billow, Laskowski.
Analysis and interpretation of data: Winemiller, Billow, Laskowski, Harmsen.
Drafting of the manuscript: Winemiller, Billow.
Critical revision of the manuscript for important intellectual content: Winemiller, Billow, Laskowski, Harmsen.
Statistical expertise: Harmsen.
Obtained funding: Billow.
Administrative, technical, or material support: Winemiller, Billow.
Study supervision: Winemiller, Laskowski.
Funding/Support: This study was funded by an unrestricted educational grant from the Spenco Medical Corporation, Waco, Tex. Both the active and sham-magnetic insoles were provided at no charge directly from the manufacturer.
Role of the Sponsor: Spenco Medical Corporation was not involved in study design, data collection, analysis, or interpretation, or in manuscript preparation, review, or approval.

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Relationship Between CCR5 Density and Viral Load After Discontinuation of Antiretroviral Therapy

To the Editor: Discontinuation of combined antiretroviral therapy (CART) improves virological control and specific immunity in some persons infected with human immunodeficiency virus 1 (HIV-1),[1] whereas in others it results in rapid viral rebound and decrease in the antiviral cytotoxic T cell responses below the pretherapeutic level.[2] The host factors responsible for these opposite consequences are largely unknown. We have recently reported that the mean number of CCR5 coreceptors at the surface of CD4 T cells (CCR5 density) is logarithmically correlated with viral load[3] and disease progression[4] during HIV-1 infection. We have explained this link by showing in vitro that CCR5 density strongly determines the efficiency of HIV-1 life cycle, particularly at the reverse transcription stage.[5] Herein we report a test of the hypothesis that CCR5 density, which is stable over time in a given individual but varies among individuals, might determine the intensity of viral rebound after cessation of CART.

Methods. We used quantitative flow cytometry[3] to measure CCR5 density on peripheral blood CD4 T cells of all chronically infected patients in our clinic who stopped antiretroviral multitherapy in an 18-month period because of physical or psychological drug intolerance (8 women and 15 men). All had CD4 T cell counts ranging from 300 to 1739 and HIV-1 RNA plasma levels below 200 copies/mL. We also measured virus load at day 30 after discontinuation of CART.

Results. The FIGURE shows a strong logarithmic relation ($r=0.644$, $P=.001$) between CCR5 expression and plasma level of HIV-1 RNA. Interestingly, beyond a threshold of 8000 CCR5 molecules per CD4 T cell, virus load rebounded above 100 000 copies/mL.

Comment. These results emphasize the notion that CCR5 density is related to in vivo virus production and may explain why virus loads before CART and after cessation of CART are comparable. Moreover, they suggest CCR5 density as a predictive factor of the effect of treatment interruption, and emphasize the possible therapeutic potential of agents that would antagonize CCR5.

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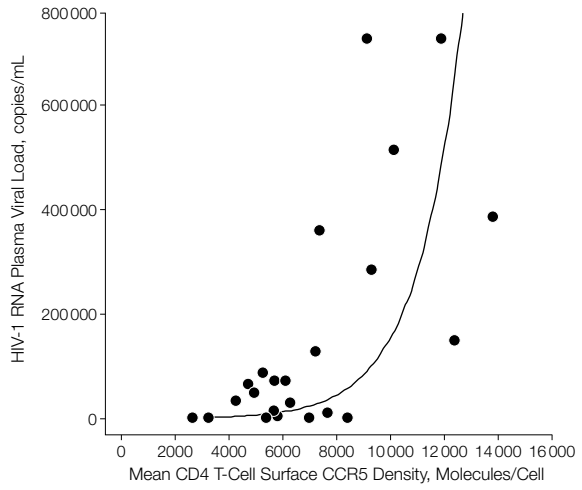
Figure. Correlation Between the Mean Number of CCR5 Molecules at the Surface of Peripheral Blood CD4 T Cells and HIV-1 RNA Plasma Level on Day 30 After Interruption of Antiretroviral Treatment



HIV indicates human immunodeficiency virus. Curved line indicates the best exponential fit for the data.

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CORRECTION

Incorrect Units: In the Original Contribution entitled "Effect of Magnetic vs Sham-Magnetic Insoles on Plantar Heel Pain: a Randomized Controlled Trial" published in the September 17, 2003, issue of THE JOURNAL (2003;290:1474-1478), some data were reported with incorrect units. In Table 1, the mean (SD) duration of pain should have been reported, not in months, but in weeks (ie, 120 [170] weeks in the nonmagnetic insole group and 85 [86] weeks in the magnetic insole group).

Relationship Between CCR5 Density and Viral Load After Discontinuation of Antiretroviral Therapy

To the Editor: Discontinuation of combined antiretroviral therapy (CART) improves virological control and specific immunity in some persons infected with human immunodeficiency virus 1 (HIV-1),[1] whereas in others it results in rapid viral rebound and decrease in the antiviral cytotoxic T cell responses below the pretherapeutic level.[2] The host factors responsible for these opposite consequences are largely unknown. We have recently reported that the mean number of CCR5 coreceptors at the surface of CD4 T cells (CCR5 density) is logarithmically correlated with viral load[3] and disease progression[4] during HIV-1 infection. We have explained this link by showing in vitro that CCR5 density strongly determines the efficiency of HIV-1 life cycle, particularly at the reverse transcription stage.[5] Herein we report a test of the hypothesis that CCR5 density, which is stable over time in a given individual but varies among individuals, might determine the intensity of viral rebound after cessation of CART.

Methods. We used quantitative flow cytometry[3] to measure CCR5 density on peripheral blood CD4 T cells of all chronically infected patients in our clinic who stopped antiretroviral multitherapy in an 18-month period because of physical or psychological drug intolerance (8 women and 15 men). All had CD4 T cell counts ranging from 300 to 1739 and HIV-1 RNA plasma levels below 200 copies/mL. We also measured virus load at day 30 after discontinuation of CART.

Results. The FIGURE shows a strong logarithmic relation ($r=0.644$, $P=.001$) between CCR5 expression and plasma level of HIV-1 RNA. Interestingly, beyond a threshold of 8000 CCR5 molecules per CD4 T cell, virus load rebounded above 100 000 copies/mL.

Comment. These results emphasize the notion that CCR5 density is related to in vivo virus production and may explain why virus loads before CART and after cessation of CART are comparable. Moreover, they suggest CCR5 density as a predictive factor of the effect of treatment interruption, and emphasize the possible therapeutic potential of agents that would antagonize CCR5.

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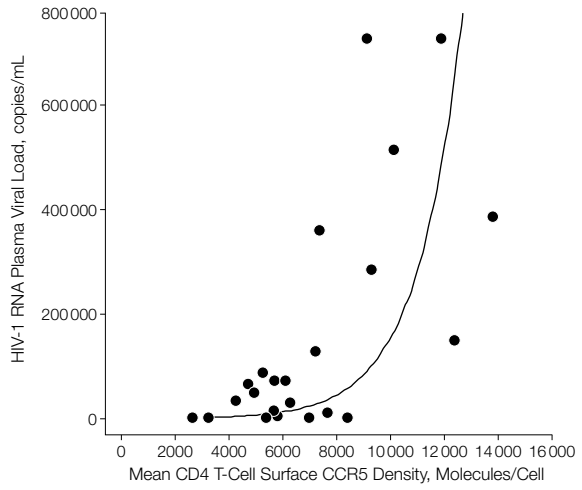
Figure. Correlation Between the Mean Number of CCR5 Molecules at the Surface of Peripheral Blood CD4 T Cells and HIV-1 RNA Plasma Level on Day 30 After Interruption of Antiretroviral Treatment



HIV indicates human immunodeficiency virus. Curved line indicates the best exponential fit for the data.

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3. Reynes J, Portales P, Segondy M, et al. CD4+ T cell surface CCR5 density as a determining factor of viral load in HIV-1-infected individuals. *J Infect Dis*. 2000; 181:927-932.
4. Reynes J, Portales P, Segondy M, et al. CD4 T cell surface CCR5 density as a host factor in HIV-1 disease progression. *AIDS*. 2001;15:1627-1634.
5. Lin Y-L, Mettling C, Portales P, Reynes J, Clot J, Corbeau P. Cell surface CCR5 density determines the postentry efficiency of R5 HIV-1 infection. *Proc Natl Acad Sci U S A*. 2002;99:15590-15595.

CORRECTION

Incorrect Units: In the Original Contribution entitled "Effect of Magnetic vs Sham-Magnetic Insoles on Plantar Heel Pain: a Randomized Controlled Trial" published in the September 17, 2003, issue of THE JOURNAL (2003;290:1474-1478), some data were reported with incorrect units. In Table 1, the mean (SD) duration of pain should have been reported, not in months, but in weeks (ie, 120 [170] weeks in the nonmagnetic insole group and 85 [86] weeks in the magnetic insole group).